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**J. Conroy · M. Agarwal · P. V. Giannoudis
S. J. E. Matthews**

Early internal fixation and soft tissue cover of severe open tibial pilon fractures

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Abstract We studied 32 consecutive patients with open distal tibial pilon fractures. All patients had radical debridement with immediate skeletal stabilisation and early soft-tissue cover with a vascularized muscle flap. The minimum follow-up was 1 (range 1–8) year. There were four superficial infections, two deep infections and two amputations. There were no long-term problems with union and no patient required an ankle fusion. Patients were assessed using the SF-36 questionnaire. There were significant differences from the US norm in physical function score ($p<0.01$), role physical score ($p<0.05$) and physical component score ($p<0.01$). Physical component score of 38.5 was significantly better ($p<0.01$) when compared with amputees from severe lower-extremity trauma. Our protocol for management resulted in a good functional outcome with low infection and amputation rates.

Résumé Nous avons étudié 32 malades consécutifs avec une fracture ouverte du pilon tibial. Tous les malades avaient un débridement radical avec stabilisation squelettique immédiate et couverture tissulaire précoce avec un lambeau musculaire vascularisé. Le minimum de suivi était une année (1à 8 années). Il y avait 4 infections superficielles, 2 infections profondes et 2 amputations. Il n'y avait pas de problèmes de consolidation à long terme et aucune arthrodèse de cheville ne fut nécessaire. Les malades ont été étudiés à partir du questionnaire SF-36. Il y avait des différences significatives selon la norme américaine du score de la fonction physique ($p<0.01$), le rôle du score physique ($p<0.05$) et le score de la composante physique ($p<0.01$). Le score composant physique de 38.5 était considérablement meilleur ($p<0.01$) comparé aux amputés pour traumatisme distal sévére. Notre protocole de gestion de ces fractures a conduit à un bon résultat fonctionnel avec un taux d'infection et d'amputation très bas.

J. Conroy · M. Agarwal · P. V. Giannoudis (✉) · S. J. E. Matthews
Department of Orthopaedics and Trauma,
St. James University Hospital,
Leeds, LS9 7TF, UK
e-mail: pgiannoudi@aol.com
Tel.: +44-113-2433144, Fax: +44-113-2065156

Introduction

Pilon fractures are usually the result of high-energy trauma and are associated with extensive soft-tissue damage. Ruedi and Allgower [17] described a method of management in 1969, including restoration of length and axis of the fibula, reconstruction of the articular surface of the distal end of the tibia, bone grafting of any defect and plating of the medial aspect of the tibia. This method was used for many years with successful outcomes in the lower-energy injuries represented in their study. However, in high-energy open injuries where extensive soft-tissue damage exists, reconstruction may be even more problematical leading to a poor functional outcome.

These types of open pilon injuries are not common and have not been adequately represented in the literature. We therefore describe our experience in managing the most severe Gustillo [8, 9] grade IIIB pilon injuries with early skeletal stabilisation and soft-tissue cover, and report on the functional outcomes in a series of patients treated in our institution.

Patients and methods

Between 1993 and 2000, 35 consecutive patients (28 men) who had sustained open (Gustillo grade IIIB) distal tibial (AO type 43B and C [13]) fractures were prospectively studied. Three patients were lost to follow-up and were excluded. The remaining 32 had reconstruction of their injury by skeletal stabilisation and muscle flap and had progressed to bony union or amputation. All of these patients had been jointly managed by our orthopaedic and plastic surgical services. Demographic details of the patients are shown in Table 1.

On admission to our hospital, all patients were assessed by the orthopaedic and plastic surgical teams, and the hospital's protocol for treating open tibial fractures was followed [7]. Treatment included immediate (within 24 h) radical wound debridement outside the zone of injury with profuse lavage, skeletal stabilisation depending on the fracture personality, and early soft-tissue cover-

Table 1 Patient demographics. *ISS* injury severity score.

Patient number	32
Mean age	43.8 years
Gender	26 male, 6 female
ISS	9–12 (mean 9)
AO classification	43B 21 43C 11
Method of skeletal stabilisation	Open reduction and internal fixation 28 External fixator 4
Flap cover	Latissimus dorsi 25 Gracilis 3 Rectus abdominis 3 Latissimus dorsi and rectus abdominis 1
Fracture union	12–78 weeks (mean 35 weeks)
Amputation	2 (6.2%)
Complications	Superficial infection 4 (12.5%) Deep infection 2 (6.2%)
Malunion	3 (9.3%)
Osteoarthritis	6 (18.8%)

age using a vascularised muscle flap with split skin graft. Twenty-eight fractures were stabilised using open reduction internal fixation techniques (plates and screws), while four fractures were treated with an external fixator. Antibiotics were prescribed for the first 5 days. Subsequent antibiotics were given according to the indications from swab cultures, usually from areas of superficial skin graft.

Early range of motion was encouraged. Routine post-operative rehabilitation included support with a plaster slab until soft-tissue stability permitted fitting of a bivalve below-knee lightweight cast. Patients were allowed to move their joints out of the cast, but weightbearing was prohibited until bone union had taken place.

Following discharge from the hospital, all patients had regular clinical and radiological assessment at the trauma clinics. They were followed up until fracture union (defined as full weightbearing without pain, and radiological callus in two planes at right angles to each other) or for a minimum of 1 year. Secondary bone-stimulating procedures were performed early whenever problems of union were considered likely, as judged by bone condition at initial surgery. These included autologous bone grafting and transport techniques. No allograft was used.

Radiographs from both the immediate post-operative period and at final follow-up were reviewed for joint reduction assessment and metaphyseal–diaphyseal alignment and graded accordingly. An excellent grade was given for <2 mm of joint incongruity and <5° of varus/valgus metaphyseal–diaphyseal angulation. A radiographic grade of satisfactory was given for >2 mm but <5 mm of joint incongruity or fracture plane separation and >5° of varus/valgus metaphyseal–diaphyseal angulation. A poor radiographic grade was given for >5 mm of joint incongruity or fracture gap and >10° of varus/valgus metaphyseal–diaphyseal angulation.

At final follow up patient's self-perceived general level of health was measured using the extensively used SF-36 questionnaire [11, 12, 24, 25]. The SF-36 results were compared with age-matched US norms for men and women in all categories. Physical and mental component summary scores (PCS and MCS) were also compared with previously published data from amputees [6].

Statistical analysis was performed using the SPSS software package (SPSS UK Ltd, Chertsey, Surrey, UK). Groups were compared using a two-tailed Student's *t*-test with $p<0.05$ being considered significant.

Results

There were 26 men and six women, with a mean age of 43.8 (16–79) years. Five patients had associated injuries. Mean ISS was 9 (range 9–12). Mean time to final follow-up was 4.2 (1–8) years. Twenty-eight patients underwent fracture stabilisation with open reduction internal fixation using indirect reduction techniques and preserving the fracture biology (Fig. 1). Two patients with metaphyseal bone loss required the application of an Ilizarov frame to reconstruct the bone defect. Mean time to application of the Ilizarov frame was 4 months. An external fixator was used in four patients for fracture stabilisation; one had a segmental defect subsequently requiring bone transport.

Soft-tissue cover was achieved with free muscle flap procedures. Twenty-five latissimus dorsi, three gracilis and three rectus abdominis flaps were used. In one patient a combination of latissimus dorsi and rectus abdominis flaps was necessary to cover the defect. In 11 patients a single acute procedure by combined orthopaedic surgery and plastic surgery teams was performed. In a further nine patients the soft-tissue cover was completed within 3 days. In six patients it was delayed beyond 1 week, with a maximum of 21 days, due to clinical circumstances independent of the leg injury.

Twenty-nine patients had anatomical reduction of fracture at primary surgery. One patient had a 2 mm step and gap at fracture site, while two patients had bone loss extending to the articular surface. Three patients had bone transport procedures performed for extensive segmental defects (3 cm, 5 cm and 8 cm respectively). Ilizarov ring fixator was used in all cases. All defects had healed at final follow-up. Four patients had superficial infection defined as infections resolving with one course of flucloxacillin and benzyl penicillin. Two patients required an amputation; one a 79-year-old diabetic woman with failure of a primary flap who underwent amputation at 2 weeks, and the other a 64-year-old farmyard worker who suffered an acute tibial infection and underwent amputation at 18 months. Seven patients required bone grafting. In three patients bone grafting was done at primary operation, in two it was delayed until 15 and 21 weeks respectively, and in a further two it was done after 1 year (maximum delay of 64 weeks).

After exclusion of the two amputees, all 30 remaining patients progressed to clinical and radiological union. Mean time to union was 35 (12–78) weeks. Six patients had loss of joint congruity and evidence of osteoarthritis on radiographs at final follow-up.

The SF-36 was completed by all 32 patients. Comparison of the SF-36 scores with the age-matched US norms showed significantly worse scores in both physical function (PF: $p<0.01$) and role physical (RP: $p<0.05$) categories (Table 2). There were no other significant differences between groups. Comparison of patient PCS and MCS to the US norm showed a significant difference in PCS ($p<0.01$) but no significant difference in MCS. We also compared our SF-36 scores with those published by

Fig. 1 Anteroposterior and lateral views of an open AO type 43C fracture in a 30-year-old male (**a**, **b**). Immediate post-operative radiographs after skeletal stabilisation and soft tissue cover showing good articular reconstruction (**c**, **d**). Anteroposterior and lateral radiographs at 5 months showing union with abundant callus formation (**e**, **f**)

Table 2 Means and standard deviations of the study group and age-matched US norms. *SD* standard deviation; *PF* physical functioning; *RP* role physical; *BP* bodily pain; *GH* general health perception; *VT* energy and vitality; *SF* social functioning; *RE* role emotional; *MH* mental health

Scale	Grade IIIB pilon fracture		Age-matched US norms	
	Mean	SD	Mean	SD
PF	57.6	21.3	84.7	9.8
RP	63.0	34.9	81.7	10.7
BP	65.4	23.5	75.2	6.1
GH	68.6	14.5	72.2	6.3
VT	64.8	21.8	61.1	2.3
SF	76.9	23.3	83.7	2.7
RE	70.4	43.7	81.4	3.8
MH	74.7	13.9	74.7	1.0

Dagum et al [6] for primary and secondary amputees after severe lower-extremity trauma. Our results showed a significant difference in PCS (38.5 versus 28.4, $p<0.01$) but not in MCS (52.8 versus 47.3, $p>0.05$).

Discussion

Severe open pilon fractures are difficult to treat and often result in a poor functional outcome. A review of the literature reveals only small series of grade IIIB open pilon fractures, usually within larger studies including closed pilon fractures [4, 21, 26]. To our knowledge this study is the largest series of grade IIIB open pilon fractures assessing long-term functional outcome. In this series stabilisation of the tibial pilon fractures was done by open reduction and internal fixation techniques in most patients. This was chosen to enable an accurate reconstruction of the distal tibial articular surface, good access to soft-tissue reconstruction and early joint motion.

Only four cases had stabilisation with an external fixator, and we noted superficial infection in all. This problem was predictable. There are other well-known disadvantages of external fixation, including poor access to soft-tissue reconstruction and increased incidence of delayed union [7]. One patient had a fixation revision by open reduction internal fixation (ORIF) with bone grafting and another was revised to Ilizarov. The remaining two where the external fixator was removed and a plaster cast was applied had delayed union at 42 and 50 weeks respectively.

Our protocol, consisting of early internal fixation with soft-tissue reconstruction was aggressive. However, the analysis of our results shows excellent union rates, low rates of infection and good functional outcome. Eleven cases were completed as a single primary procedure, and in 20 cases soft-tissue coverage was accomplished within 72 h. Most problems we encountered were associated with deviation from this protocol, particularly use of external fixation and delay in soft-tissue cover.

We consider our aims in management of open tibial pilon fractures as sequential, initially to achieve limb salvage by healing of soft tissues without infection and then to achieve bony union. Overall the primary rate of union was 100%, excluding amputation. However, a review of other series revealed variable results. Bourne et al. [5] reported a 25% non-union rate in type III fractures (Ruedi-Allgower [18]) treated by ORIF. On the other hand Sands [19] reported only one case of non-union in 64 patients treated with ORIF. Other authors have reported non-union rates varying from 0 to 12% [1, 15, 16, 27].

Malunions involving the distal tibial metaphysis or articular surface occur as result of inadequate fracture reduction and stabilisation. The distal tibia develops a varus tilt, which may cause abnormal loading of articular surfaces leading to accelerated joint wear and unsatisfactory results. In our series three patients had a malunion with all showing radiological evidence of osteoarthritis at final follow-up. Other series have reported variable rates of malunion ranging from 3 to 42% [1, 15, 16, 19, 22, 27].

Infection prevention is crucial in managing open fractures. Our deep infection rate was low at 6%. Other authors have reported a variable infection rate—Ovadia and Beals [14] reported a rate of osteomyelitis of 7%; Teeny and Wiss [22] an even higher rate of osteomyelitis of 37%. At the other end of the spectrum, Sands et al. [19] published an infection rate of 5%. All of the above series included both open and closed pilon fractures. We believe that the low infection rate in our series was because of multiple factors, namely adequacy of debridement, early skeletal stabilisation and the subsequent obliteration of dead space by a healthy, well vascularised flap. We also wish to point out the dire consequences should a deep infection occur. Both of our patients who had deep infection ultimately underwent amputation. Amputation rates in other published series ranged from 0 to 7.7% [15, 16, 19, 21, 27].

Post-traumatic arthritis affecting the ankle joint may occur following pilon fractures. Studies have shown that the final functional result after pilon fractures correlates strongly with the accuracy of articular reduction [1, 22, 23]. Six patients in our series had radiological evidence of ankle-joint arthritis at final follow-up. However, none of these patients had reached a stage that required an ankle arthrodesis. A review of literature reveals that studies reporting results of ORIF for pilon fractures quote a salvage arthrodesis rate of 0–26% [2, 3, 10, 20]. We feel that our use of internal fixation allowed accurate reconstruction of the articular surface thus reducing the incidence of joint problems. However, we are aware that some patients in our series will eventually require ankle arthrodesis.

Distal tibial pilon fractures involve the articular surface, and some loss of ankle motion is expected. For this reason joint motion was instituted as soon as the patient's general condition permitted. Patients were supported in a bivalve cast but were allowed to move their ankle joint out of the cast. Our routine is supported by contemporary literature [1]. In a series of 56 patients, Babis et al. [1] had the most favourable results with regard to ankle range of motion in patients treated with ORIF and mobilised early.

In previously published studies, a variety of outcome measures to assess functional outcome have been used, which often were not validated [2, 4, 10, 14, 17, 18]. In this study a validated, self-administered questionnaire of general health to focus specifically on the patient's perspective of their health status after surgery was used rather than a complex variety of different clinical parameters. The results show that our management protocol results in significantly lower scores in PF and RP of SF-36 as compared to US norms. The PCS was also significantly lower than the US norm. This means patients had more difficulty performing physical activities such as bathing or dressing and had more problems with work or other daily activities. This might be expected after serious lower-limb injury. It is interesting that there were no significant differences in the other categories of the SF-36, or the MCS. This suggests patients had good general health, vitality and energy. They had no difference in emotional problems, felt generally happy and had no significant limitations due to pain. Comparing our SF-36 results with those from amputees after lower extremity trauma we see a significant fall ($p<0.05$) in the PCS both from primary and secondary amputation.

In conclusion, our protocol for treating severe open pilon fractures results in a decrease in patient's physical functioning compared to US norms but is significantly better than an amputation in similar circumstances. However, these findings reflect injury severity. All our patients were satisfied for retaining their limbs. Our protocol, consisting of early fracture stabilisation and soft-tissue cover, appears to provide good long-term functional outcome with low infection (13%), amputation (6%) and ankle-fusion rates (0%).

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